GAS LAWS OVERVIEW

Created by: Julio Cesar Torres Orozco

Background: The gas laws we will be discussing in this handout were created over four centuries ago, and have been helpful for scientist to find pressures, amounts, volumes and temperatures of gases under different conditions, and the relationship there exists between these variables.

The fundamental gas laws are the following: **Boyle's Law, Charles' Law,** and **Avogadro's Law**. We will also discuss the **Gay-Lussac law** When we combine these Laws, we get the **Combined Gas Law** and the **Ideal Gas Law**.

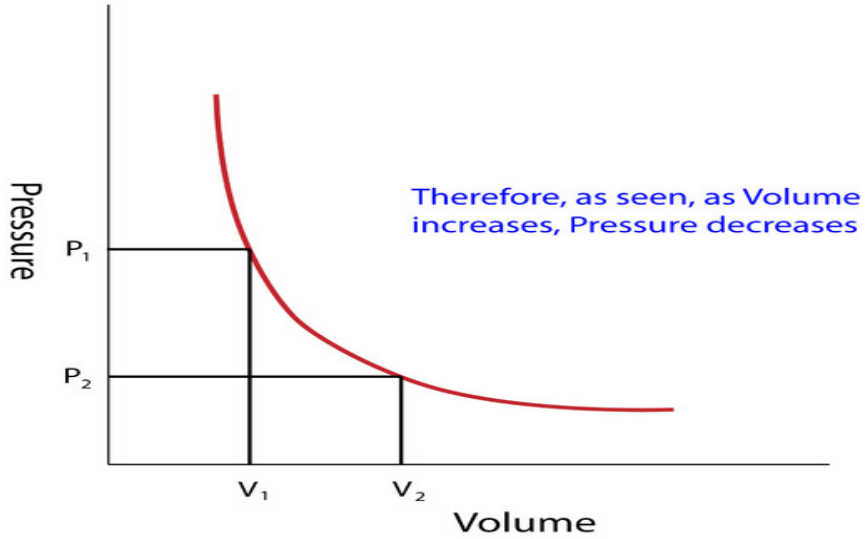
GAS LAWS:

- Boyle's Law: In 1662, Robert Boyle discovered the relationship between **pressure** and **volume**, assuming constant temperature and amount of gas. If the temperature remains constant, as the volume of a container increases, the pressure the gas will exert will decrease. Therefore:

RELATIONSHIP: **Pressure is inversely proportional to volume**

EQUATION: $P_1 \times V_1 = P_2 \times V_2$

GRAPHIC REPRESENTATION:



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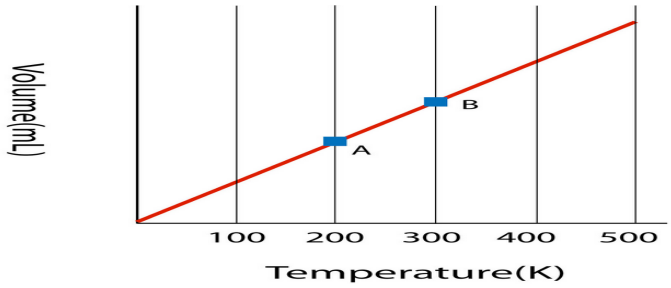
- **Charles' Law:** In 1787, Jacques Charles discovered how temperature and volume are related, assuming that the amount of gas and pressure are constant. An increase in temperature will also increase the volume of the gas. Therefore:

RELATIONSHIP: **Volume is directly proportional to temperature**

EQUATION:

$$\frac{V_1}{T_1} = \frac{V_2}{T_2}$$

GRAPHIC REPRESENTATION:



- **Gay-Lussacs' Law:** This law shows the relationship there exists between temperature and pressure of gasses. Given a constant volume, if the temperature increases, the pressure will also increase. Therefore:

RELATIONSHIP: **Pressure is directly proportional to temperature**

EQUATION:

$$\frac{P_1}{T_1} = \frac{P_2}{T_2}$$

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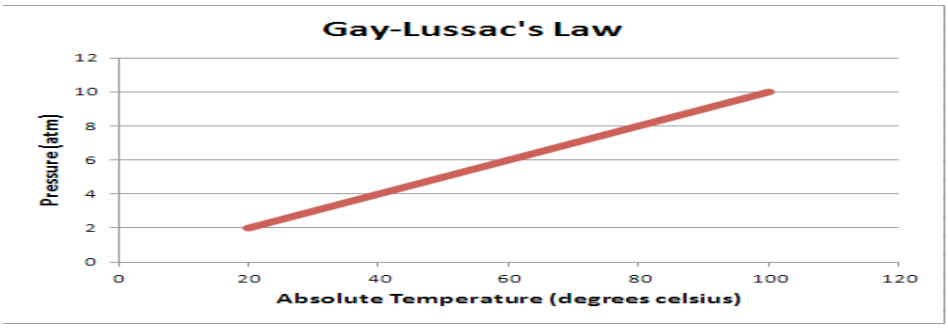


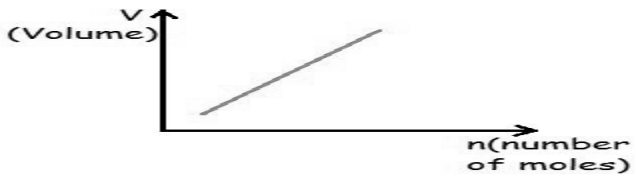
- **Avogadro's Law:** In 1811, Amedeo Avogadro was able to identify the correlation between the amount of gas (n) and its volume, assuming that temperature and pressure are constant. An increment in the amount of gas will also increase the volume of gas. Therefore:

RELATIONSHIP: **Volume is directly proportional to amount of gas**

EQUATION:

$$\frac{V_1}{n_1} = \frac{V_2}{n_2}$$

GRAPHIC REPRESENTATION:



- **Combined Gas Law:**

$$\frac{P_1 V_1}{T_1} = \frac{P_2 V_2}{T_2}$$

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- Ideal Gas Law: When the fundamental gas laws are combined we get the ideal gas law. Therefore:

EQUATION: $\mathbf{P\,V = n\,R\,T}$

P= Absolute pressure of gas **V**= Volume of ideal gas **n**= Amount of gas **T**= Absolute temperature **R**= Gas constant

**Note*: The gas constant (R) has different values that can be used, depending on the units. The most common ones are the following:

$$\mathbf{8.3145\ Joules \cdot mol^{-1} \cdot K^{-1}\ (SI\ Unit) = 0.082057\ L \cdot atm \cdot K^{-1} \cdot mol^{-1}}$$

PRACTICE PROBLEMS:

1. If 22.5 L of nitrogen at 748 mm Hg are compressed to 725 mm Hg at constant temperature. What is the new volume?

2. A gas with a volume of 4.0L at a pressure of 205kPa is allowed to expand to a volume of 12.0L. What is the pressure in the container if the temperature remains constant?

3. A gas occupies 900.0 mL at a temperature of 27.0 °C. What is the volume at 132.0 °C?

4. If 15.0 liters of neon at 25.0 °C is allowed to expand to 45.0 liters, what must the new temperature be to maintain constant pressure?

5. Maybelline Cousteau's backup oxygen tank reads 900 mmHg while on her boat, where the temperature is 27 C. When she dives down to the bottom of an unexplored methane lake on a recently discovered moon of Neptune, the temperature will drop down to –183 C. What will the pressure in her backup tank be at that temperature?

6. 50 g of nitrogen (N_2) has a volume of ___ liters at STP.

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7. A gas is heated from 263.0 K to 298.0 K and the volume is increased from 24.0 liters to 35.0 liters by moving a large piston within a cylinder. If the original pressure was 1.00 atm, what would the final pressure be?

Answer Key:

1. 23.2 L	5. 270 mmHg
2. 68.3 KPa	6. 39.8 L
3. 1215 mL	7. 0.777 atm

References: The following resources were referenced in the creation of this handout: Chemistry Libretext's page on gas laws and New Providence School District's gas law worksheet.